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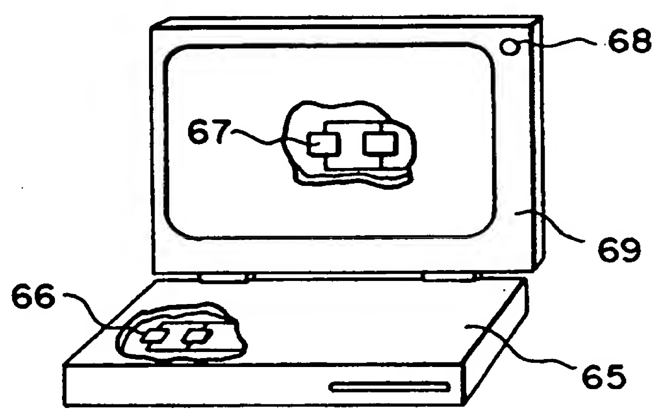
(54) Title: MULTIMEDIA PERSONAL COMPUTER WITH ACTIVE NOISE REDUCTION AND PIEZO SPEAKERS

(57) Abstract

This invention involves the integration of piezoelectric speaker panels (66, 67) and microphones (68) into a personal computer (65) with a sound card to form a novel multimedia computer. In addition noise cancellation electronics and algorithms are also applied to enhance performance of a voice recognition system included in the computer.



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MULTIMEDIA PERSONAL COMPUTER WITH ACTIVE NOISE REDUCTION AND PIEZO SPEAKERS

This invention is concerned with a new multimedia computer with a variety of new display, audio, input and active noise reduction features. In many applications that require a sound source, such as multimedia PC's, the size and weight of the speaker systems are particularly cumbersome. The need to carry speakers separately from the personal computer or lap top is especially troublesome when traveling. Conventional loudspeakers, while able to reproduce sound well, require a large amount of space and weight. Space requirements are not easily reduced because of the need for a moving coil to drive the diaphragm. In addition to the problems associated with space and weight, the magnetic field produced by the driving element in conventional speakers would distort the display on a CRT, prohibiting installation of such a speaker in a monitor.

Background Art

Piezoelectric loudspeakers have been proposed as an alternative to moving coil loudspeakers. Such a device was described by Martin in U.S. Patent No. 4,368,401 and later by Takaya in U.S. Patent No. 4,439,640. Both inventions dealt with attaching a disc shaped piezoelectric to a diaphragm. Martin's device used a thick glue layer (10 to 50% of the carrier plate thickness) between a carrier plate and the piezoelectric ceramic. The adhesive layer served to attenuate resonance. Takaya accomplishes the same through the use of a film with a smaller Q factor than the diaphragm. Both inventors specify disc shape diaphragms and piezoceramic plates. Kompanek in U.S. Patent No. 3,423,543 uses a plurality of ceramic wafers made of piezoelectric materials such as lead zirconate-lead titanate mixtures of various shapes. Conductive layers are affixed to both sides of the wafer and then glued to a flat plate. Kompanek states that the plate is preferably made of a conductive metal such as steel but may be of plastic or paper with a conductive layer thereon forming the surface.

Another such device in U.S. Patent No. 4,352,961 to Kumada, attempts to improve the frequency response further by using various shapes for the diaphragm, such as an ellipse. He also claims the ability to form the speaker from transparent piezoceramic materials such as lanthanum doped zirconium titanate so that the speaker can be used in applications such as watch covers and radio dials. He also uses a bimorph to drive the diaphragm rather than a single layer of ceramic. All of the above methods use a flat panel driven by a piezoelectric ceramic device and make no attempt to use a three dimensional structure to improve the sound quality. The diaphragm must be attached to some type of frame and clamped to the frame.

Bage, Takaya and Dietzsch in U.S. Patent No. 4,779,246 all discuss methods of attaching the diaphragm to a support frame. Early efforts used piezoelectric ceramics to drive conical shapes reminiscent of those found in loudspeakers. Such devices can be found in Kompanek, U.S. Patent No. 3,423,543 and Schafft, U.S. Patent No.'s 3,548,116 and 3,786,202. Schafft discusses building a device suitable for use in loudspeakers. This device is of much greater complexity than flat panel speakers and is not suitable for applications where a low profile speaker is needed. In order to constrain the center of the diaphragm from moving, Bage in U.S. Patent No. 4,079,213 uses an enclosure with a center post. He claims that this reduces the locus of nodal points to the location of the center post and therefore improves the frequency response of the device. The enclosure is used to support the center post and has openings to provide for pressure relief, and does not improve the acoustic performance.

The use of microphone arrays has been discussed by Kanamori in U.S. Patent No. 5,058,170 using both spatial and temporal two dimensional filters. This invention includes the application of a linear array in lap top computers and video display units (VDUs) for desk top applications. Beam forming with sensor elements is also discussed in the open literature in a paper by Van Veen and Buckley, entitled "Beam forming: A versatile Approach to Spatial Filtering", IEEE, ASSP Magazine April 1988.

Brief Description Of Invention

Current multimedia computers are plagued with two problems. One problem is the portability of speaker systems currently used in multi-media systems. A second problem is that voice recognition systems in multi-media computers do not perform well in noisy environments. Voice recognition is a process by which human speech is digitized and analyzed to identify certain words or phrases. This would enable the user to speak commands to the computer that are currently executed with the keyboard or the mouse. This process requires excellent signal to noise ratios from the microphone. For this reason, voice recognition systems require high quality microphones with good sensitivity, flat frequency response and low noise floors. The current means of achieving this is through the use of a pressure gradient microphone. Unfortunately this requires the speaker to place the microphone in very close proximity to his mouth, since the signal produced by a pressure gradient microphone degrades with the square of distance from the microphone.

This invention provides solutions to both of these problems. The application of piezoelectric elements made from PZT to the internal walls of a desk top computer or to the inside of the display panel of a lap top computer converts these elements into speakers. One objective of this invention is to provide a three-dimensional loudspeaker driven by a plurality of piezoelectric wafers that yields efficient conversion of electrical

energy into acoustical energy. A further objective is to reproduce stereophonic sound by using multiple flat panel speakers integrated into a three-dimensional structure. Another objective is to provide an enclosure that can be populated with electronics, such as for a multimedia PC, video monitor, television, laptop computer, radio, etc., while at the same time serving as a loudspeaker.

An additional objective is to use the volume of the enclosure to improve the quality of stereophonic reproduction. In particular, the air mass can be used to improve the low frequency performance of the speaker system. Openings in the box are used both for tuning and to allow airflow for both convective and forced air cooling. A duct is added to the opening to direct airflow, adjust the acoustical properties of the speaker and provide a means of canceling fan noise. Still another objective is to provide a means for integrating the diaphragm with a mounting frame so that the speaker can be used as a lid to an enclosure. By building the speakers into the computer housing or the display, the multi-media computer can be made considerably more portable.

In addition to converting the PC case of a lap top display into a speaker system, and reducing fan noise, a further objective is to provide a built-in variable sensitivity microphone into the display housing for voice processing application. Voice recognition is sensitive to voice levels. Therefore, a key in improving voice recognition is a means of controlling microphone sensitivity. A micro machined microphone, that has a sensitivity which is determined by its bias voltage, is one way of achieving this. This also provides the means of determining the range over which the microphone will listen. By adjusting the microphone sensitivity and by varying software parameters the user can determine how close or how far away from the computer he wishes to operate his voice recognition system. The application of this highly sensitive and controllable microphone allows for hands free operation of voice recognition systems. In fact, recent experiments with existing voice recognition software has yielded a 100% success rate at distances of 4 feet away from the microphone. At distances as large as 12 feet away, voice recognition rates were as high as 70%. The second advantage of the micro machined microphone is that the microphone is extremely small and can be built directly onto existing circuitry within the computer. The small size of the microphones would also permit the formation of microphone arrays that could be used to form a high degree of directionality. The variable sensitivity possible with micro machined microphones provides a means by which the array can be controlled in range as well as direction.

By building the microphone into the lap top version of the personal computer and by turning the display panel into a speaker system a multi-media system can be made as portable as any existing lap top computer. The introduction of the microphone also provides a means of equalizing the piezoelectric speaker to improve sound quality.

Accordingly, it is an object of this invention to provide a new improved multimedia computing system.

Another object is to utilize piezo elements in a new relationship as speakers on planar surfaces.

Another object is to combine active noise reduction and piezos in a personal computer to reduce fan noise, create a quiet zone around the microphone and/or the microphone arrays, improve voice recognition performance and improve duct tuning.

A further object of this invention is to use piezos in personal computers to aid audio reproduction and give better mid-range performance.

Yet another object of this invention is to provide piezo speakers for use in personal computers, monitors and the like to facilitate slimmer styling and light weight construction.

Another object of this invention is to employ micro machined microphones with improved sensitivity to enhance operation of personal computers with voice recognition circuits.

A still further object of this invention is to provide high sensitivity, flat frequency response microphones for computers and monitors.

Description of the Drawings

Figure 1 is a rear view of the preferred embodiment,

Figure 2 is a side view of the interior of the preferred embodiment.,

Figure 3 is a cross section of the preferred embodiment showing a monolithic patch on each panel,

Figure 4 is a cross section of one of the piezoceramic driven panels showing a multilayer patch,

Figure 5 is a side view of another embodiment in which a duct is added to the fan for the purpose of reducing fan noise,

Figure 6 illustrates the means of driving two piezoelectric elements. Also illustrated in Figure 6 is a possible location of a micro machine microphone,

Figure 7 details the drive circuitry for the piezoelectric speaker system (the drawing illustrates a single audio channel, stereo is achieved through two sets of circuitry),

Figure 8 is a plot of the frequency response of the piezoelectric speaker system,

Figure 9 illustrates the concept of placing the piezoelectric elements and a microphone into a lap top computer,

Figure 10 illustrates the concept of placing the piezoelectric elements and a microphone into a VDU for a desk top computer,

Figure 11 illustrates the concept of a phased array of elements into a lap top computer with piezoelectric speakers,

Figure 12 illustrates the concept of a phased array of elements into a VDU for a desk top computer with piezoelectric speakers,

Figure 13 illustrates the means by which a microphone array could be used to control listening direction and range,

Figure 14 is plot of microphone array gain as a function of angle and frequency,

Figure 15 is a diagram of the multimedia components integrated into a basic PC system,

Figure 16 illustrates a digital version of active noise cancellation,

Figure 17 is a diagram of an analog version of active noise cancellation,

Figure 18 is a block diagram of the equalization circuit of this invention,

Figure 19 is a perspective view of a non-enclosure piezo driven structure, and

Figure 20 is a perspective view of a second non-enclosure driven structure.

Description of the Preferred Embodiments of Speaker System

Figure 1 illustrates the configuration of the preferred embodiment. The speaker enclosure 10 is made of metal or plastic. In experiments, the enclosure was made of 3/16" plastic. Overall dimensions were 10"x16"x6" and were chosen to represent a typical personal computer enclosure. Each side was cut individually and then glued together. A variety of other methods such as vacuum forming can also be used. An opening in the rear 11 serves as an air inlet in which a fan for cooling is placed. A second opening in the front (not shown) allows air to exit the enclosure. Piezoceramic patches 12, 13 are glued to the large side of the enclosure and are electrically connected to a power amplifier 14. The number of piezoceramic patches can be varied depending on the type of material used in the enclosure and can be attached on either the inside and/or outside of the enclosure. The large sides of the enclosure were selected because they would radiate sound most efficiently. It is possible to attach piezoceramic patches to the smaller sides as well. For the demonstration system a 30 watt amplifier was used along with a 20:1 step up transformer. Because of the low power consumption a much smaller amplifier would normally be used. The input to the amplifier 14 is connected to an audio signal generator. A side view of the enclosure 10 is shown in Figure 2. The rear of the enclosure contains an opening 22 for a fan 21 covered by a grill and air filter 23. The interior of the enclosure contains electronics such as those found in a personal computer. Piezoceramics 12, 13 are attached to the large panel. The front vent 25 is also shown. Location of the fan and vent openings are not critical to performance of the system. A cross section of the enclosure 10 is shown in Figure 3. Piezoceramic patches 30, 34 are adhered to the sides of the enclosure with adhesive layers 33, 35. Electrodes 31, 32, 36,

and 37 made of copper, are attached to top and bottom sides of the piezoceramic patch. When a voltage is applied across the top 31, 36 and bottom 32, 37 electrodes a change in the length of the piezoceramic patch 30, 34 will create a strain that will result in a bending of the panel. The direction of the panel deflection depends on the polarity of the voltage. In some applications it may be desirable to reduce voltage levels needed to drive the piezoceramic patches for safety or other reasons. In this case a multilayer piezoceramic patch of the type described U.S. application, serial number 08/057,944, incorporated by reference herein, can be used. Figure 4 illustrates a four layer actuator. Four layers of piezoceramic material 41, 42, 43 and 44 are bonded together and then adhered to the panel 47 with an epoxy. Electrodes 45,46 are placed between each layer such that when a voltage is applied between them the polarity alternates between each layer.

Figure 5 shows still another embodiment in which a duct 50 is added to the cooling fan 52. The duct 50 serves two purposes. First, the volume of air in the duct is used to tune the enclosure in order to provide improved low frequency response. Such methods are common in loudspeaker enclosure design. Second, an active noise reduction system 51 is added to attenuate noise from the cooling fan 52. One method involves an adaptive feed forward system such as that described in U.S. Patent No. 4,122,303 to Chaplin. An upstream microphone 53 senses noise from the fan 52 and input to a digital signal processor (DSP) 56. A second microphone 54 monitors the residual noise after cancellation and is also an input to the DSP 56. The DSP 56 calculates the canceling signal and outputs it to a loudspeaker 55 that is capable of generating a noise spectrum identical to that of the fan 52. Material 57 such as fiberglass or open cell foam can be used to passively reduce noise

Figure 6 illustrates the driving of two piezoelectric electric 58, 59 driven in by the same audio amplifier 60. The devices are connected in parallel. Such an arrangement is required when the panel being driven is particularly stiff.

Figure 7 illustrates the basic circuitry of the piezoelectric speaker system. The audio output from the computer sound card is fed into the input 61 of a standard audio amplifier 62. The output from the amplifier is fed into a step up transformer 63, before going into the piezoelectric elements 64 such as those available from Morgan-Matroc Corporation. The step up in voltage is required since the piezoelectric elements require higher voltage than conventional loud speakers. The amplifier 62 is commercially available as PA-26 APEX from APEX Corporation as a linear amplifier.

Figure 8 is a plot of the frequency response of the piezoelectric speakers in a PC case similar to the one depicted in Figure 1. The curve indicates that the frequency response is roughly flat from 200 Hz to 10Kz.

Figure 9 illustrates another embodiment of the invention for a lap top computer application. The lower case 65 has piezoelectric elements 66 placed in the lower corner. Piezoelectric elements 67 and a microphone 68 are placed in the lid 69 of the lap top computer. This is one means of achieving a portable multimedia system.

Another embodiment of the invention is shown in Figure 10 for a video display unit (VDU) to be used with a desk top computer. The piezoelectric elements 70, 71 are placed on the inner walls of the VDU shell 72. A microphone 73 is placed on the top of the VDU. The use of piezoelectrics in the case of a VDU containing a cathode ray tube or CRT is particularly important since the magnetic drives in conventional speakers makes their use in VDU's impossible, due to the effect of the magnetic field on the display. The application of the piezoelectric elements and the microphone is a method of producing a self contained multimedia system for desk top applications.

Figure 11 illustrates another embodiment of the invention for a lap top computer application. The lower case 74 has piezoelectric elements 75 placed in the lower corner. Piezoelectric elements 76 and a microphone array consisting of three microphones 77, 78, 79 are placed in the lid 80 of the lap top computer. This is one means of achieving a portable multimedia system where the microphone system can be highly directional to reduce the effects of background noise in the voice recognition system. An active noise reduction system 107 is used to enhance provision of a quiet zone.

Figure 12 illustrates another embodiment of the invention for a VDU used with a desk top computer. The piezoelectric elements 81, 82 are placed on the inner walls of the VDU shell 83. A microphone array consisting of three microphones 84, 85, 86, is placed on the top of the VDU. This produces a self contained multimedia system for desk top applications where the micro system provides a high degree of directionality to reduce the effects of background noise.

Figure 13 illustrates the means for processing the microphone array data. Three microphones 87, 88, 89 are fed into analog to digital converters 90, 91, 92. The output from the analog to digital converters feed into finite impulse filters 93, 94 ,95 filter. The output from the filters are summed at a summing junction 96 to produce the composite digital output 97. An automatic gain adjustment algorithm 98 is used to control the output of multiplying digital to analog converters 99, 100, 101. The analog to digital converters provide a means for changing the bias voltage on the micro machined microphones. By changing the bias voltage the sensitivity of each element is controlled (signal gain may also be controlled on electret microphones but requires additional circuitry). This, in conjunction with the digital signal processor, provides a means of controlling the range, as well as directivity in the microphone array. The filters and the gain adjustments can also reside on a single DSP(digital signal processor) chip such as an Analog Devices MSP55 with stereo input and output. An additional embodiment

includes the analog to digital and the digital to analog converters on a ASIC chip along with the digital signal processor.

Figure 14 is a plot of the directivity of a microphone array consisting of three microphone elements placed 7.5 cm apart. Directivity is calculated at 0.5 meters away from the array. The plot displays gain as function of frequency and angle of incidence of the impinging sound, zero degrees being normal to the array.

Figure 15 is a block diagram of the basic multimedia computer, illustrating the integration of the multimedia features and the active noise control into a typical PC system. The microphone input 102 is fed into the sound card where it is filtered and converted into digital information. The digital data is transmitted across the AT/Local Bus 104 to the main processor 105 where the voice recognition software resides. The sound card also converts digital audio information from the main processor into an analog signal which is fed into the audio amplifier 106 that drives the piezoelectric speaker. Two audio channels are required for stereo operation. The active noise reduction (ANR) circuitry 107, is used to eliminate the fan noise in the power supply 108. The ANR is also used to quiet the area near the microphone to reduce the effects of background noise in the voice recognition. The ANR is also used to reduce noise generated by the hard and floppy disk drives 110. The ANR is illustrated in block diagram form in Figure 16 and 17. The ANR is either purely analog or digital signal processor, DSP, based depending on the flexibility and degree of performance required. The RAM memory board 109, the hard and floppy disk drives 110, and the video graphics adapter VGA 111 are shown to detail the complete PC system.

Figure 16 illustrates a digital signal processor based version of the active noise cancellation system. The microphone output 112 is fed into an analog to digital converter 113 which provides a digital version of the noise spectrum to the digital signal processor 114. The digital signal processor contains an algorithm designed to analyze the noise and generate the appropriate wave form to cancel the noise. The drive signal calculated on the DSP is converted to an analog audio signal by the digital to analog converter 115, which is fed into an audio amplifier 116 and then into the speaker 117.

Figure 17 illustrates the cascade of low pass 118 and band pass 119, 120 stages of the signal conditioning segments of the analog active noise cancellation system. The low pass filter is essentially a single operational amplifier with the appropriate resistors and capacitors. The band pass filters are variable state filters consisting of four operational amplifiers and the appropriate resistors and capacitors. The microphone 121 and the speaker 122 make up the essential elements of the electro-acoustic feedback loop. By choosing a very broad band microphone to assure linearity in phase and by placing the foam filled cavity behind the speaker to improve the linearity of the speaker, the remaining non linearity in the systems are compensated for by adjusting the properties

of the low pass, and the band pass filters. The properties of the low pass and band pass filters are adjusted by changing the values of resistors and capacitors in the each of the filters.

Figure 18 illustrates the means of achieving equalization of the speaker system using the microphone 124 as part of an audio feedback circuit. The signal from the microphone 124 represents the electrical equivalent of the acoustic output of the piezoelectric speaker 125. The equalizer 126 compares the microphone signal to the electrical audio input 127 normally used to drive the speaker. The drive of the speaker is adjusted by the equalizer until the electrical signal from the microphone matches the intended electrical audio signal as closely as possible. The equalizer may be realized through the use of a differential operational amplifier or a FIR filter.

Figure 19 illustrates the application of a piezo element 128 to one side 129 of an open three-dimensional structure 130 to form a directional speaker system. An additional element 131 can be placed on the adjacent side 132 to create stereophonic sound. This is a non-enclosure structure.

Figure 20 illustrates another embodiment of an open speaker system. Piezoelectric elements 133, 134 are placed on adjacent sides 134, 135 of panels to form a dihedral corner reflector. The third surface 137 provides a support means for the speaker system. Again, a non-enclosure structure is used.

Having described the invention, what is claimed is

CLAIMS

1. A three dimensional speaker system, said system including

structure means having three dimensions, each dimension having a generally planar surface means, each said planar surface means adapted to vibrate in response to stimulation of one of them,

said structure means generally enclosing an air volume,

at least one transducing means located on one of said planar means, said transducing means adapted to vibrate in response to a signal current to reproduce sound within and around said structure means,

whereby said entire structure means acts as a loudspeaker.

2. A system as in claim 1 wherein said transducing means comprises a piezoelectric element means.

3. A system as in claim 2 wherein said piezoelectric element means is composed of a laminate of separate piezoelectric panels, each adapted to be separately stimulated.

4. A system as in claim 1 wherein there are at least two transducing means each of which comprise separate piezoelectric means.

5. A system as in claim 4 wherein at least one of said separate piezoelectric means is composed of a laminate of separate piezoelectric panels.

6. A system as in claim 4 wherein each said separate piezoelectric means are located on the same planar surface means of said structure means.

7. A system as in claim 4 wherein each said separate piezoelectric means are located on different planar surface means of said structure means.

8. A system as in claim 1 and including a port means adapted to tune the low frequency response of said structure means and to allow for airflow therein and out.

9. A system as in claim 8 wherein said port means includes a fan means adapted to enable said structure to have improved cooling.

10. A system as in claim 9 and including a duct means adapted to enable tuning and control of noise generated by operation of said fan means.

11. A personal computer system having unique transducing means to thereby enhance audio inputs and outputs, said system including

a three dimensional enclosure means with a display means thereon,

said enclosure means having multiple planar surface wall means,

a transducing means mounted on at least one of said planar surface means,

said enclosure means adapted to act as a speaker in response to activation of said transducing means,

control means adapted to receive inputs and convert them to visual display and audio outputs.

12. A system as in claim 11 wherein said planar surface means includes a pair of surface means larger than the other planar surface means.

13. A system as in claim 11 wherein said transducing means comprises a piezoelectric panel means.

14. A system as in claim 13 wherein said piezoelectric panel means comprises a laminate of at least two piezoelectric elements, each element adapted to be separately activated by said control means to produce an audio output.

15. A system as in claim 13 wherein said piezoelectric panel means are bonded to the inside wall means of said enclosure means.

16. A system as in claim 15 wherein said enclosure means is constructed of plastic.

17. A system as in claim 11 and including input means adapted to produce inputs to said control means.

18. A system as in claim 17 wherein said input means comprises microphone means.

19. A system as in claim 18 including bias voltage means adapted to control the sensitivity of said micromachined microphone means.

20. A system as in claim 17 wherein said input means include a voice recognition circuit means and microphone means adapted to function with said voice recognition circuit means to produce input signals to said control means.

21. A system as in claim 20 wherein said microphone means comprises multiple microphones mounted on said three-dimensional enclosure means adjacent said display means.

22. A system as in claim 20 wherein said control means includes integrated circuit means with analog to digital and digital to analog converters, and

said microphone means comprising an array of microphones, said integrated circuit means adapted to control said microphones.

23. A system as in claim 20 wherein said control means includes a computer sound card means, an audio amplifier and a step-up transformer means,

said transducing means comprising piezoelectric means,

said computer sound card means adapted to produce an audio output which is fed into said audio amplifier and through said step-up transformer means to said piezoelectric means to cause said latter means to vibrate to produce said audio output.

24. A system as in claim 20 wherein said control means including

analog to digital conversion means adapted to process said microphone array inputs,

finite impulse filter means adapted to receive the output from said conversion means,

summing means adapted to receive the output of said impulse means and adapted to produce a composite digital output,

automatic gain adjustment means adapted to process said composite digital output, and

multiplying digital to analog conversion means adapted to receive said processed output and to change the sensitivity of said microphone means.

25. A system as in claim 24 wherein said microphone means comprises a micromachined microphone, said digital to analog conversion means adapted to change the bias voltage on said microphone to thereby control its sensitivity and consequently, the range and directivity thereof.

26. A system as in claim 24 wherein said filters and gain adjustments comprise a single digital signal processing chip.

27. A system as in claim 20 wherein said control means also includes active noise control means.

28. A system as in claim 27 and including power supply means with a cooling fan means, said active noise control means adapted to attenuate noise generated by said fan means.

29. A system as in claim 27 wherein said active noise control means is adapted to attenuate noise in the area of said microphone means so as to eliminate the effects of background noise in said voice recognition circuit means.

30. A system as in claim 27 and including a disk drive means associated with said control means and adapted to produce audio signal inputs into said control means to drive said transducing means,

said active noise control means adapted to attenuate noise associated with said disk drive means.

31. A system as in claim 27 wherein said active noise control means includes a digital signal processor means adapted to analyze the offending noise and generate a counter wave to cancel the offending noise.

32. A system as in claim 31 wherein said digital signal processor means includes a cascade of low pass and band pass stages.

33. A system as in claim 32 wherein said low pass stage is a single operational amplifier and said band pass stage are variable stage filters consisting of operational amplifiers.

34. A system as in claim 33 wherein said transducing means and said microphone means are selected and placed relative to each other so as to constitute an electro-acoustic feedback loop.

35. A laptop computer employing integrated piezoelectric panels and microphones in a novel arrangement, said computer comprising

a main housing means,

lid means physically and operatively connected to said main housing means, said lid means being configured as a hollow enclosure,

display means on said lid means and adapted to provide a visual display,

piezoelectric panel means on said lid means and adapted in conjunction with said hollow enclosure, to provide an audio output,

control means situated within said main housing means and adapted to drive said piezoelectric audio output and said visual display means in response to input signals, and

input means adapted to provide inputs to said control means.

36. A computer as in claim 35 wherein said piezoelectric panel means comprise multiple piezoelectric elements mounted on said lid means adjacent said display means.

37. A computer as in claim 36 wherein said piezoelectric elements are bonded to the inner walls of said lid means.

38. A computer as in claim 36 and including additional piezoelectric elements mounted in said main housing means.

39. A computer as in claim 35 and including additional piezoelectric panel means in said main housing means adapted to produce a second audio output which, in conjunction with said first audio output produces a stereophonic effect.

40. A computer as in claim 35 wherein said piezoelectric panel means are designed to produce improved sound reproduction at low frequencies and improved mid-range performance.

41. A computer as in claim 35 wherein said input means includes at least one microphone means.

42. A computer as in claim 41 wherein said input means consists of an array of electret microphones and including variable gain amplification means to adjust their sensitivity.

43. A computer as in claim 42 and including a voice recognition means adapted to function with said microphone array to produce selected inputs to said control means.

44. A computer as in claim 43 and including active noise control means adapted to improve the performance of said voice recognition means and to create a zone of quiet adjacent said microphone array.

45. A computer as in claim 35 wherein said input means includes a voice recognition means and microphone means adapted to function with said voice recognition means to produce input signals to said control means.

46. A computer as in claim 45 including multiple microphones mounted adjacent said display means on said lid means.

47. A computer as in claim 46 wherein said control means includes integrated circuit means with analog to digital and digital to analog converters, and

said microphone means comprising an array of microphones, said integrated circuit means adapted to control said microphones.

48. A computer as in claim 45 wherein said control means includes a computer sound card means, an audio amplifier and a step-up transformer means,

said computer sound card means adapted to produce an audio output which is fed into said audio amplifier and through said step-up transformer means to said piezoelectric means to cause said latter means to vibrate to produce said audio output.

49. A computer as in claim 45 wherein said control means includes

analog to digital conversion means adapted to process said microphone means inputs,

finite impulse filter means adapted to receive the output from said conversion means,

summing means adapted to receive the output of said impulse means and adapted to produce a composite digital output,

automatic gain adjustment means adapted to process said composite digital output, and

multiplying digital to analog conversion means adapted to receive said processed output and to change the sensitivity of said microphone means.

50. A computer as in claim 49 wherein said microphone means comprises a micromachined microphone, said digital to analog conversion means adapted to change the bias voltage on said microphone to thereby control its sensitivity and consequently, the range and directivity thereof.

51. A computer as in claim 49 wherein said filters and gain adjustments comprise a single digital signal processing chip.

52. A computer as in claim 45 wherein said control means also includes active noise control means.

53. A computer as in claim 52 and including power supply means with a cooling fan means, said active noise control means adapted to attenuate noise generated by said fan means.

54. A computer as in claim 52 wherein said active noise control means is adapted to attenuate noise in the area of said microphone means so as to eliminate the effects of background noise in said voice recognition circuit means.

55. A computer as in claim 52 and including a disk drive means associated with said control means and adapted to produce audio signal inputs into said control means to drive said transducing means,

said active noise control means adapted to attenuate noise associated with said disk drive means.

56. A computer as in claim 52 wherein said active noise control means includes a digital signal processor means adapted to analyze the offending noise and generate a counter wave to cancel the offending noise.

57. A computer as in claim 56 wherein said digital signal processor means includes a cascade of low pass and band pass stages.

58. A computer as in claim 57 wherein said low pass stage is a single operational amplifier and said band pass stage are variable stage filters consisting of operational amplifiers.

59. A monitor for use in a visual/audio communications mode, said monitor comprising

a housing means having top, rear and side walls,

a video display means mounted in said housing and adapted to display video output through the open front of said housing means,

audio amplification means associated with said video display means,

piezo means located on at least one wall of said housing means and adapted to be driven by said audio amplification means to provide an audio output in conjunction with said video output.

60. A monitor as in claim 59 wherein there are piezo means on opposing walls of said housing so as to produce a stereophonic effect.

61. A monitor as in claim 59 and including microphone means located atop saiid housing means adapted to input to said video display means to produce selected video/audio output.

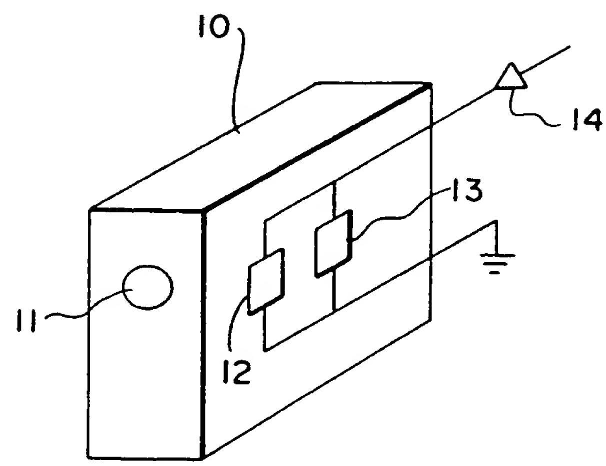


Fig. 1

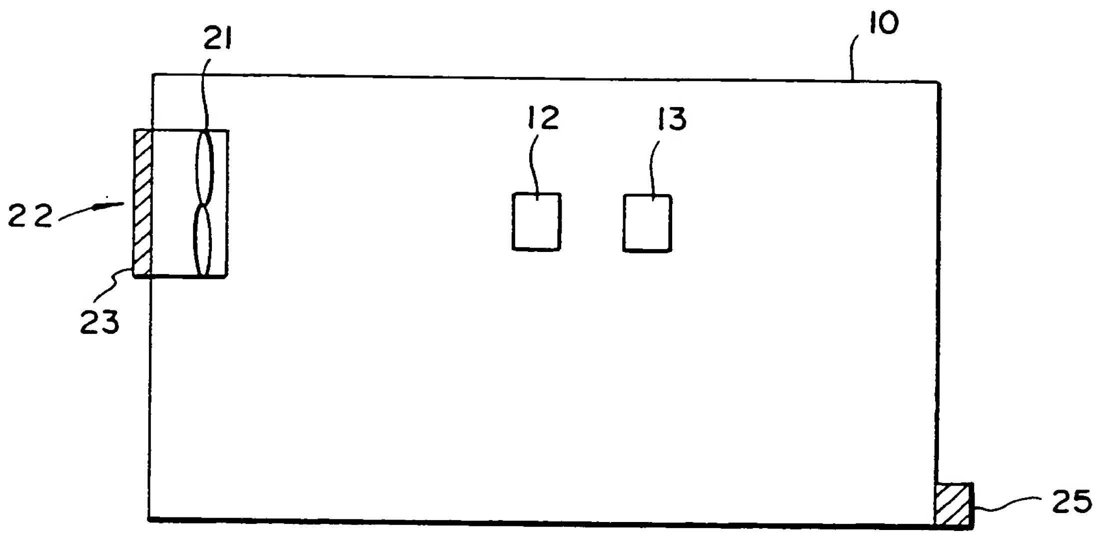


Fig. 2

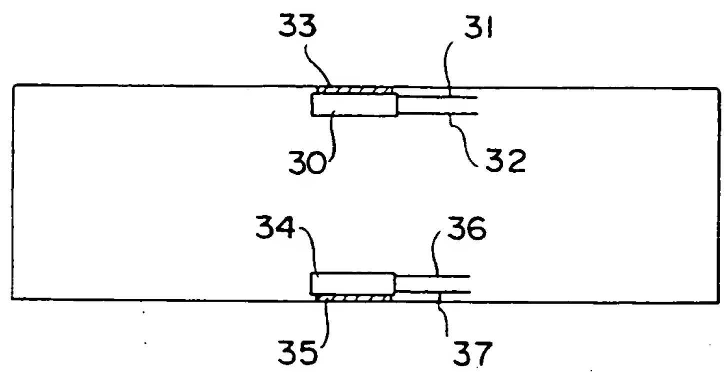


Fig. 3

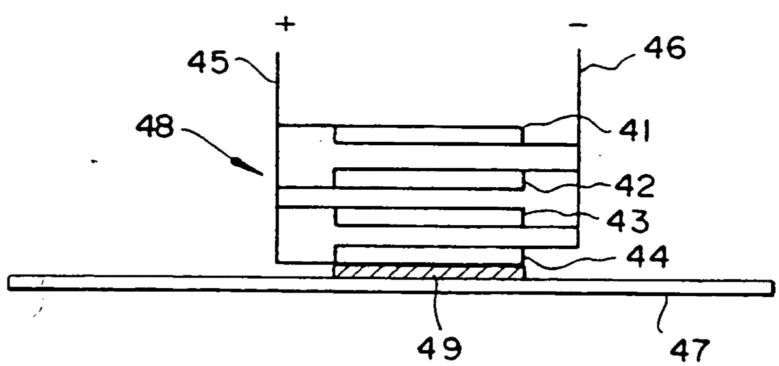


Fig. 4

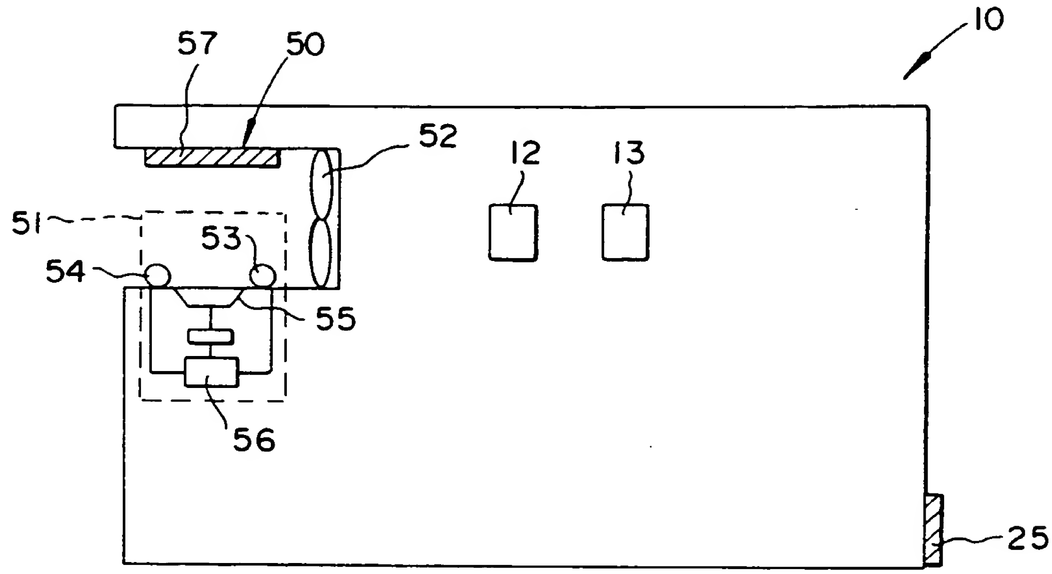


Fig. 5

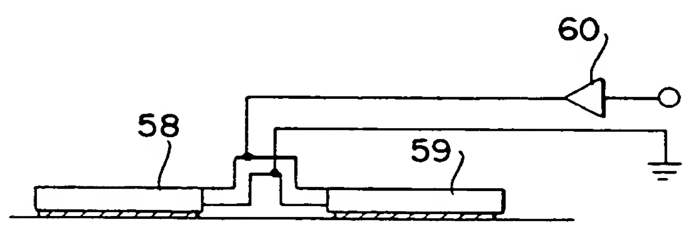


Fig. 6

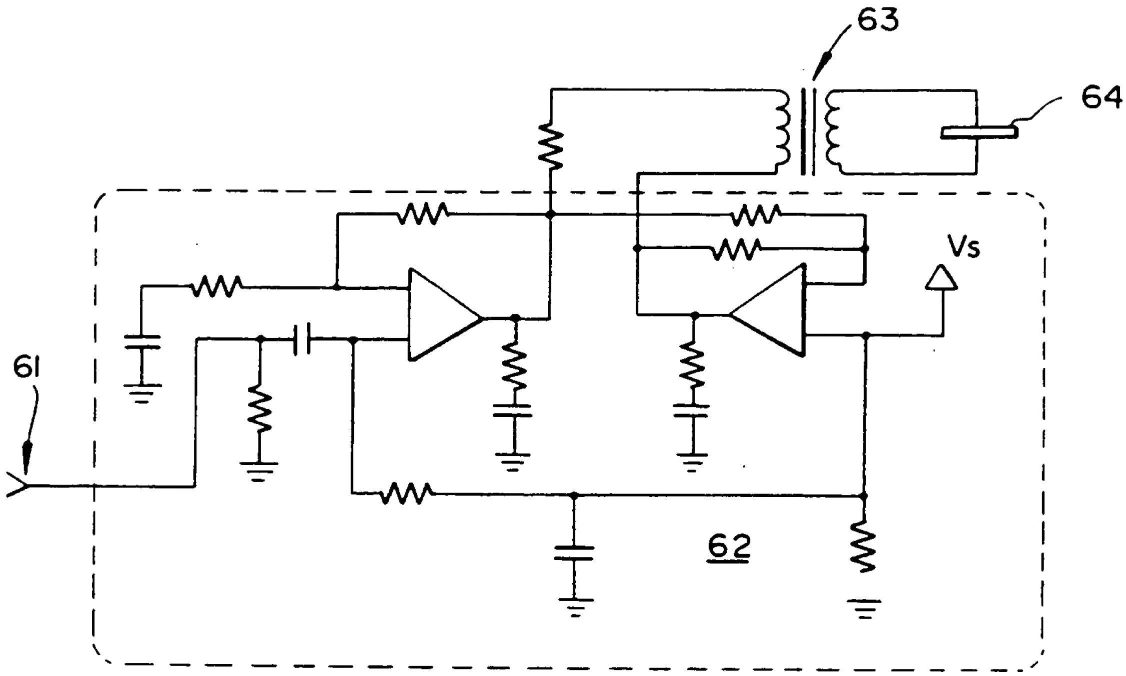


Fig. 7

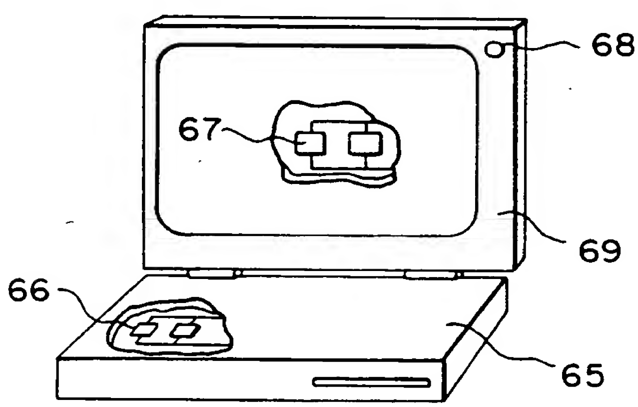


Fig. 9

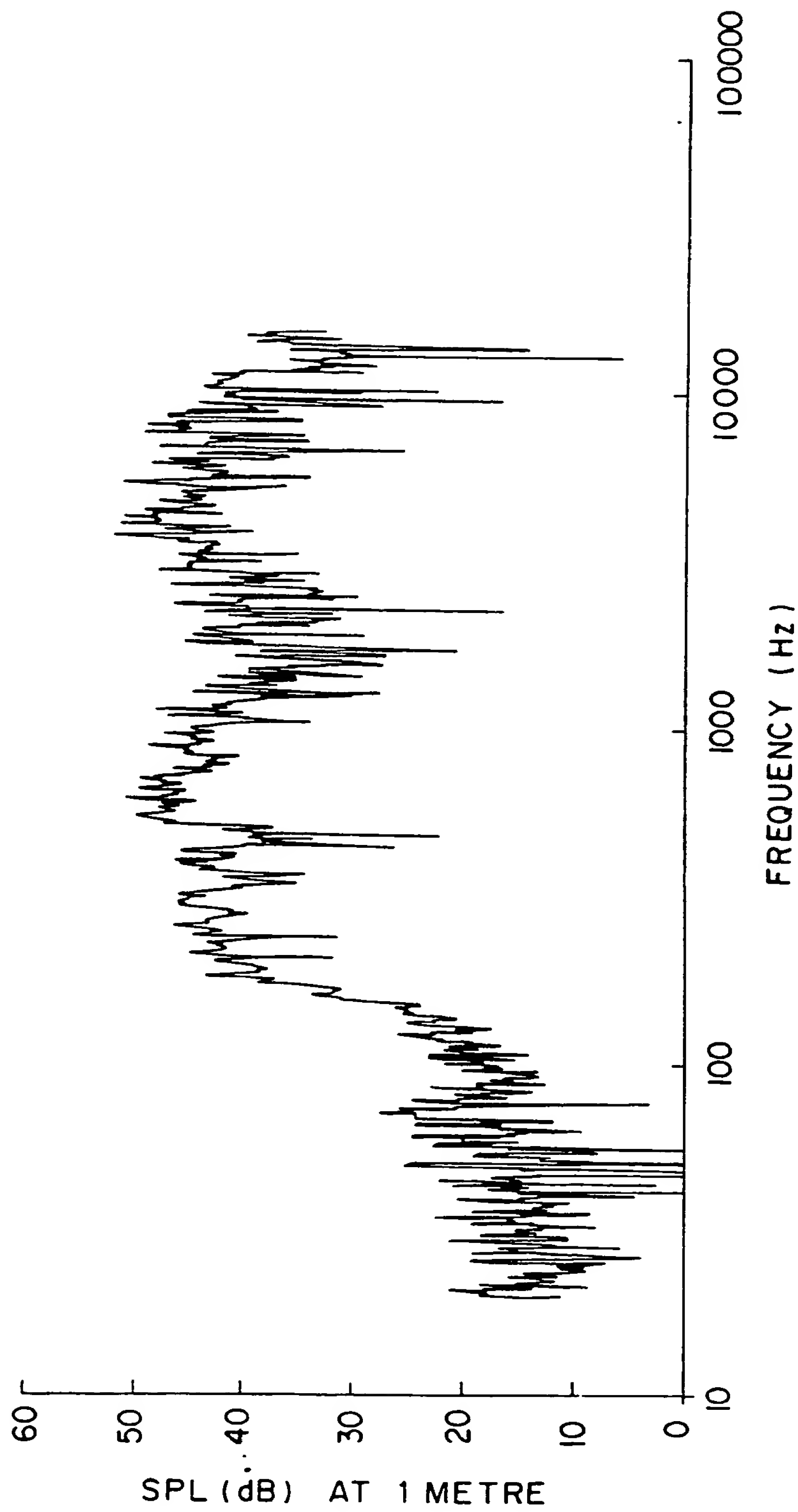

FREQUENCY (Hz)
10
100
1000
10000
100000
SPL (dB) AT 1 METRE
0
10
20
30
40
50
60

Fig. 8

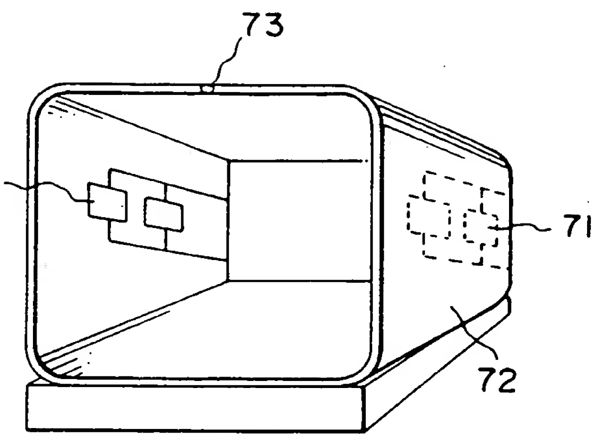


Fig. 10

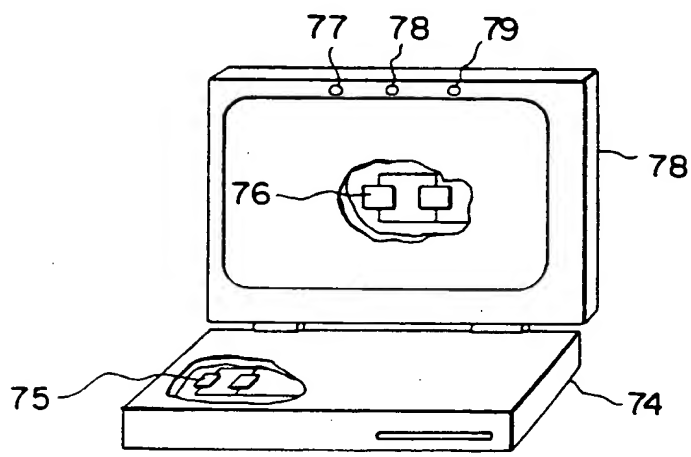
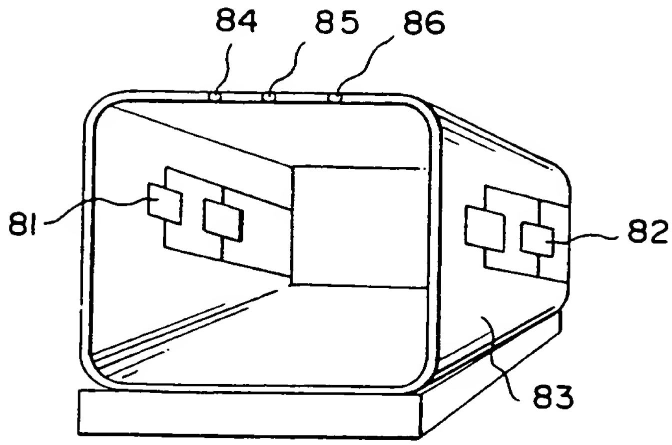
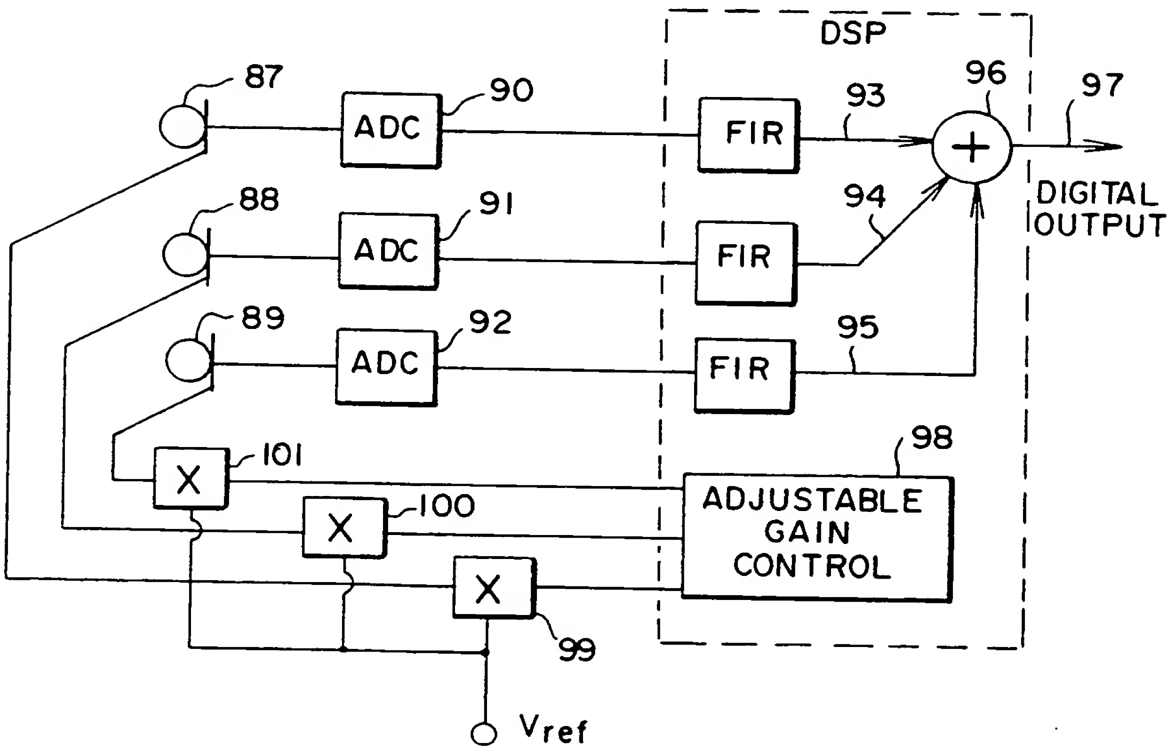


Fig. 11



84
85
86
81
82
83

Fig. 12



DSP
87
88
89
ADC
ADC
ADC
90
91
92
FIR
FIR
FIR
93
94
95
96
97
DIGITAL OUTPUT
98
ADJUSTABLE GAIN CONTROL
X
X
X
101
100
99
Vref

Fig. 13

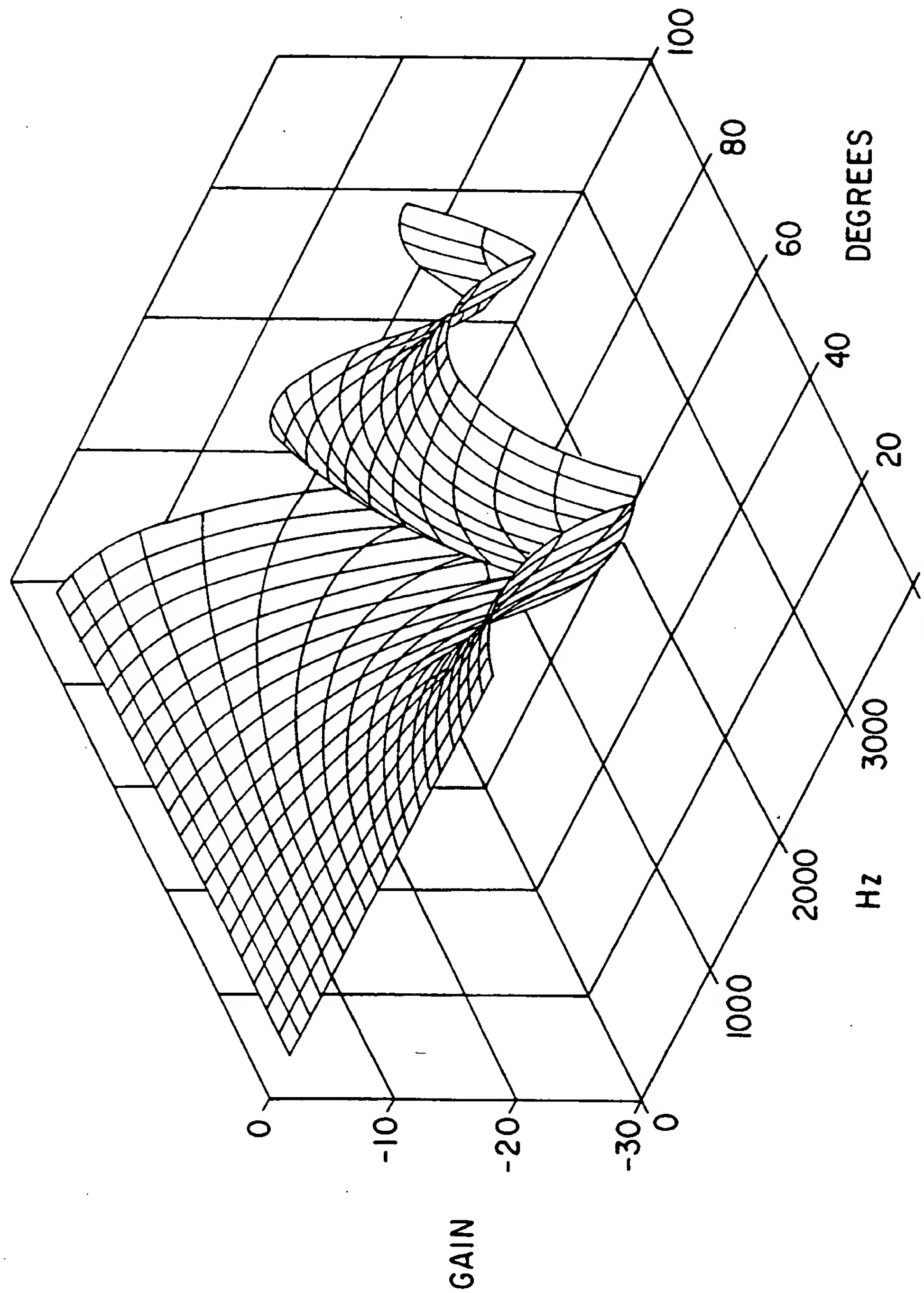


Fig. 14

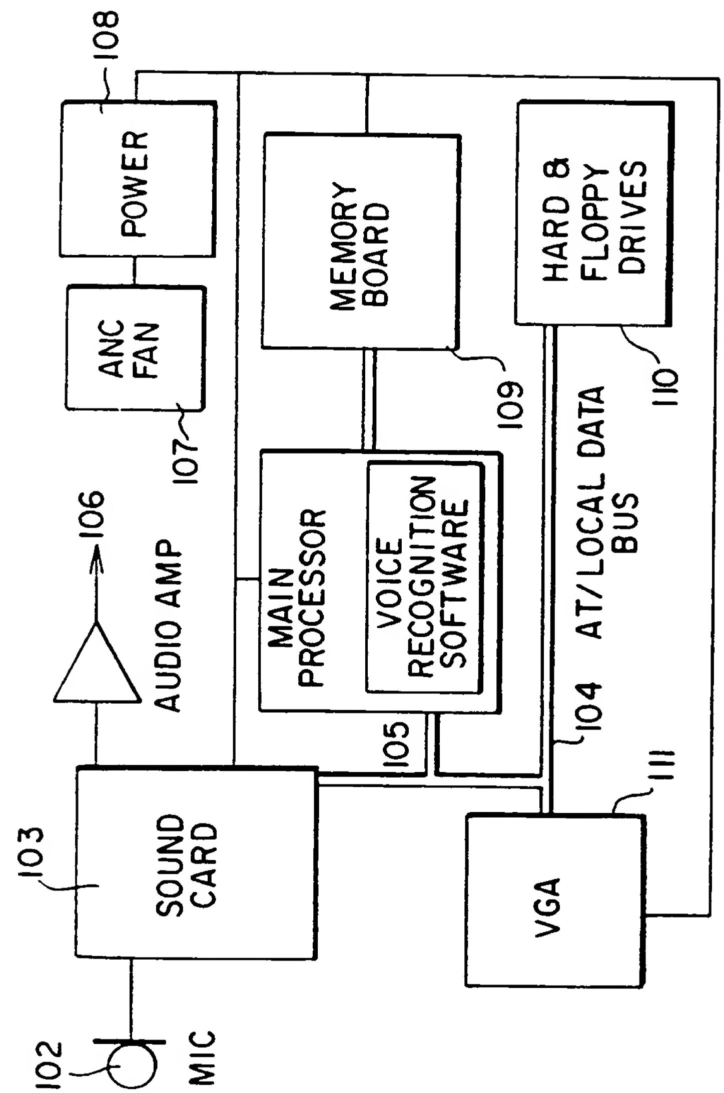

108
POWER
ANC
FAN
107
106
AUDIO AMP
MEMORY
BOARD
109
MAIN
PROCESSOR
VOICE
RECOGNITION
SOFTWARE
HARD &
FLOPPY
DRIVES
110
AT/LOCAL DATA
BUS
104
105
111
103
SOUND
CARD
VGA
102
MIC

FIG. 15

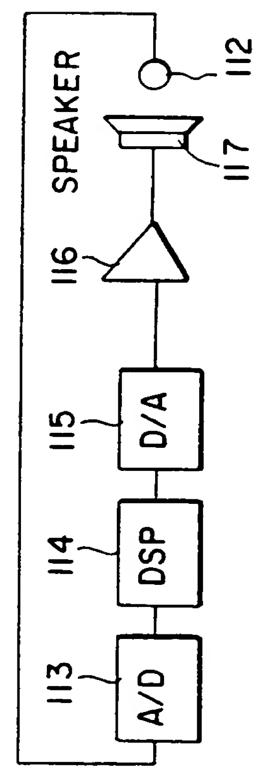

SPEAKER
112
117
116
115
D/A
114
DSP
113
A/D

FIG. 16

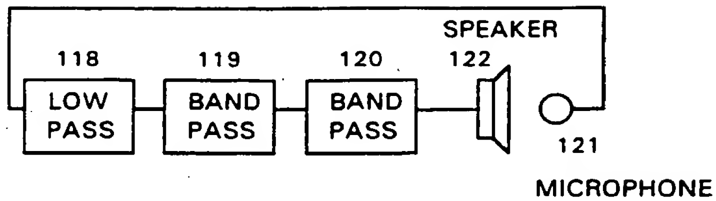

SPEAKER
118
119
120
122
LOW PASS
BAND PASS
BAND PASS
121
MICROPHONE

FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/05720

A. CLASSIFICATION OF SUBJECT MATTER	
IPC(6) :G10K 11/16	
US CL :381/24, 71, 110, 190, 191; 348/552, 729, 738, 836	
According to International Patent Classification (IPC) or to both national classification and IPC	
B. FIELDS SEARCHED	
Minimum documentation searched (classification system followed by classification symbols)	
U.S. : 381/24, 71, 110, 190, 191; 348/552, 729, 738, 836	
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched	
None	
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)	
None	

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, A, 1-245795 (ITO) 29 SEPTEMBER 1989, see Figures 5A-5C and Abstract.	1-10
Y	GB, A, 2,088,951 (WARNAKA ET AL) 16 JUNE 1982, see Figure 5 and Abstract.	10
Y	Damark - The 'Great Deal' Catalog, Damark International, Inc., June 1990, "Bondwell Superslim 286 Laptop."	11-24, 26-31, 52,55
Y	IBM Technical Disclosure Bulletin, Volume 31, No. 8, January 1989, "Audible Noise Suppression," pp. 256-258.	27-31,44, 52,53,55
Y	IEEE ASSP Magazine, April 1988,"Beamforming: A Versatile Approach to Spatial Filtering," Van Veen et al , pages 4-23.	24,26,42-44,46,47, 49,51

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 06 AUGUST 1995	Date of mailing of the international search report 01 SEP 1995
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer P. W. Isen
Facsimile No. (703) 305-3230	Telephone No. (703) 305-4386

Form PCT/ISA/210 (second sheet)(July 1992)*

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,144,451 (YAMAMOTO ET AL) 01 SEPTEMBER 1992, see Abstract, Figures 1,2, and column 2, lines 15-17.	11-24,26-31,35-49,51-56,59-61
Y	US, A, 4,368,401 (MARTIN ET AL) 11 JANUARY 1983, see Figure 1 and Abstract.	13-16,35-49,51-56,59-61
Y	US, A, 4,410,761 (SCHICKEDANZ) 18 OCTOBER 1983, see Abstract and column 4, line 57 to column 5, line 23.	36-39
Y	US, A, 4,558,184 (BUSCH-VISHNIAC ET AL) 10 DECEMBER 1985, see Abstract and Figures 1-2.	19
Y	US, A, 4,665,549 (ERIKSSON ET AL) 12 MAY 1987, see Abstract and Figures 1-2.	1-10
Y	US, A, 4,817,152 (LEE) 28 MARCH 1989, see Abstract and Figures 1-3.	35-49,51-56,59-61
Y	US, A, 5,046,103 (WARNAKA ET AL) 03 SEPTEMBER 1991, see Abstract and Figures 1-2.	27-31
Y	US, A, 5,267,323 (KIMURA) 30 NOVEMBER 1993, see Abstract and Figures 4,7,8,11.	18,20-31,42-44,46,47,49,51-56
Y	US, A, 5,291,556 (GALE) 01 MARCH 1994, see Abstract and Figure 1.	11-24,26-31